Identification of Vibration Exposure Disorder in Operators of Compaction Roller, Mobile Crane, Tracked Excavator with Breaker and Industrial Truck through Field Survey

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Abstract

The questioner survey was carried out with 66 operators of industrial off-road vehicles namely compaction roller, mobile crane, tracked excavator and industrial truck characterized with the prevalence of symptoms of musculoskeletal disorders in the neck, shoulders, hand, upper and lower back among drivers of industrial off-road vehicles due to Whole Body and Hand Transmitted vibration. The results indicate that drivers of industrial tracked excavator with breaker have an increased risk of symptoms from the neck, shoulder, thoracic and hand arm regions. There was no increased risk of low back pain in operators of compaction roller, mobile crane and industrial trucks. This indicates that factors such Whole Body Vibration (WBV) and (HTV) may be an important factor in determining the risk of symptoms in the neck, shoulder thoracic regions and hand-arm.

Keywords

Off-road Vehicles; Whole Body Vibration; Musculoskeletal Disorders; Hand Arm Vibration

Introduction

The aim of this study was to characterize the prevalence of symptoms of musculoskeletal disorders in the neck, shoulders, hand, upper and lower back among drivers of industrial off-road vehicles due to Whole Body and Hand Transmitted vibration. A comprehensive study of drivers operating off road vehicle is contemplated to assess their perception about their jobs and the difficulties faced by them. As the first step a survey was conducted through questionnaire for about 66 operators of industrial off-road vehicles around Tiruchirapalli District, India. All the 66 workers are employed as drivers and randomly selected. Since the vehicles are operated by men, only men were included in this study. The operators were a random sample from the general driving population in the same region, with an age ranging from 20 to 40. In the analysis, only drivers who had worked professionally with industrial off-road vehicles for at least 3 years were included. The sampled survey includes24 drivers of compaction roller, 15 drivers of mobile crane, 9 drivers of tracked excavators with breaker and 18 industrial truck drivers through questionnaire filled by interview method, conducted by this investigator.

Methods and Materials – Questionnaire Survey

Each individual estimated his exposure duration time in total number of hours of driving an industrial off-road vehicle. Based on the description of job titles and work duties, occupations were classified. If the current employment duration was less than one year, the previous job was also classified. The same procedure was undertaken for the drivers' previous employment. After segregation the jobs were classified as (1) exposed to WBV or ergonomic risk factors and (2) not exposed. The respondents also gave details about their smoking habits (Table 1). Subjective symptoms were asked using VINET (Vibration Injury Network) Health Surveillance Questionnaire (Annexure), which includes items with dichotomized response alternatives regarding symptoms (ache, pain or discomfort) originating from different regions of the musculoskeletal system at some point during the previous 12 months.

TABLE 1 SUBJECTS VIBRATION EXPOSURE

	Compaction roller	Mobile crane	Tracked excavators with breaker	Industrial truck drivers
Sample size	24	15	9	18
Age	29 (22-39)	34(24-45)	32 (23-44)	35 (25 - 49)
Exposure Duration in hours				
Total hours logged	11,523	9796	8890	23780
(range)	(4220- 22789)	(889-48790)	(984-36240)	(8345-90768)
Logged Previous year*(h)*	1711	1910	2058	1623
(range)	(0-3996)	(332- 4411)	(558- 2890)	(67-3890)
Smoking (n)				
Current smokers	15	9	4	12
Never smoked	3	4	2	4
Smoked Earlier	6	2	3	2
Vibration Exposure (%)				
Current Job	100	100	100	100
Previous Job	82	73	57	77

Those who reported symptoms also answered additional items on the consequences of each symptom for their working capacity, such as not being able to manage daily work at some point during the past 12 months (severe symptoms). Further, the questionnaire comprised items on whether the workers had symptoms they believed were associated to operating industrial off-road vehicles. They also gave their subjective estimation of exposure to unpleasant movements (shock, jolt, irregular sway)

Results and Discussion

Prevalence of Symptoms

The prevalence of symptoms is larger in the neck, shoulder and thoracic regions in drivers of tracked excavators compared to the industrial off-road vehicles. The driver of tracked excavators with breaker also shows increased prevalence of severe symptoms in the neck, shoulder and lower back compared to other industrial off-road vehicles considered for the study. There is a significant increased risk of low back pain for driver operating excavators (Table 2).

Elbow, wrist, knee and feet region show less prevalence of symptoms as compared to neck, shoulder and back. The discomfort level was higher in elbow compared to wrist, knee and feet (Table 3). Among operators of industrial off- road vehicles, tracked excavators show more prevalence symptoms in hand and leg region. There is no evidence of health hazard in mobile crane and industrial truck in the feet region.

TABLE 2 MUSCULOSKELETAL SYMPTOMS IN NECK, SHOULDERS, UPPER AND LOWER BACK

	Industrial off-road vehicle operators			
Body region	Compaction roller	Mobile crane	Tracked excavators with breaker	Industrial truck drivers
n	24	15	9	18
Neck				
Prevalence (%)	41.7	40	77.8	44.4
Severe Symptoms	3	4	6	3
Shoulder				
Prevalence	8	5	6	6
Severe Symptoms	2	4	6	3
Lower Back				
Prevalence	7	4	6	5
Severe Symptoms	3	3	5	3
Upper back				
Prevalence	3	2	4	2
Severe Symptoms	1	1	3	1

TABLE 3 PREVALENCE OF VIBRATION EXPOSURE SYMPTOMS IN ELBOW, WRIST, KNEE AND FEET

Body region	Industrial off-road vehicle operators			
	Compaction roller	Mobile crane	Tracked excavators with breaker	Industrial truck drivers
n	24	15	9	18
Elbows				
Left	3	2	3	2
Right	4	3	4	3
Wrists				
Left	1	1	2	1
Right	2	1	2	2
Knees				
Left	2	1	2	1
Right	3	2	2	2
Feet				
Left	0	0	0	0
Right	1	0	1	0

The drivers reported that driving an industrial off-road vehicle negatively influenced their health. Between 34 and 42% of the driving groups reported that present (previous 3 months) and earlier episodes of illness and disorders were related to driving an industrial off-road vehicle. Experience of vertical vibration, fore/aft vibration and side-to-side vibration are the most common among tracked excavators with breaker attachment (45%) compared to 15 and 19 % among compaction roller and Mobile crane drivers respectively.

The outcomes show an increased risk of neck, shoulder and thoracic symptoms for drivers of tracked excavator with breaker in this study and increased risks of low back pain as well. The symptom of musculoskeletal disorders in elbow, wrist, knee and feet is little greater pronounced in right side of the body with higher exposure to elbow.

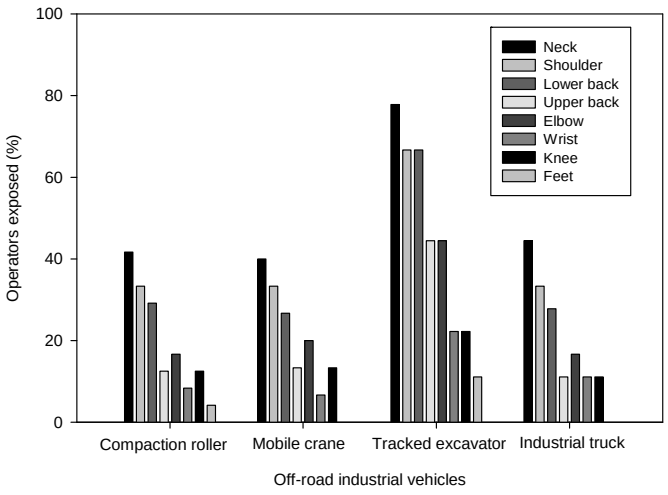

FIG. 1 PERCENTAGE OF INDUSTRIAL OFF-ROAD VEHICLE OPERATORS WITH SYMPTOMS OF VIBRATION EXPOSURE IN DIFFERENT BODY SEGMENT

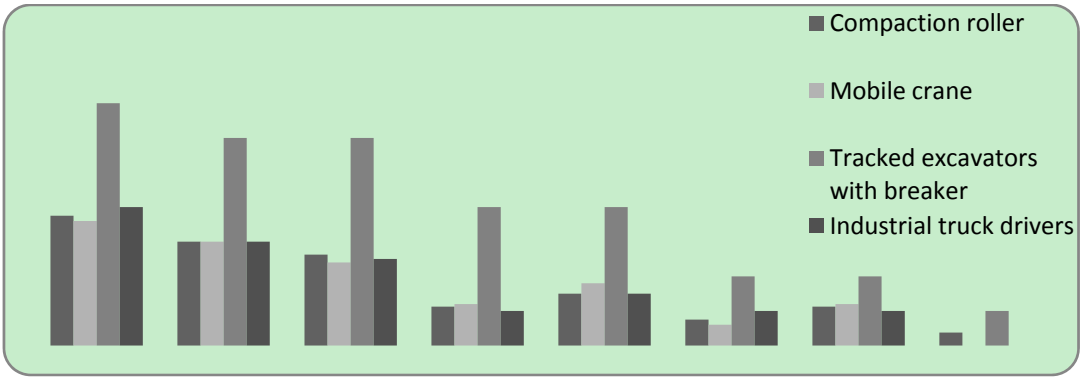

FIG. 2 SYMPTOMS OF VIBRATION EXPOSURE IN DIFFERENT BODY SEGMENT

Comparison with Other Studies

The findings of an increased risk of neck/shoulder symptoms for the group of off-road industrial Vehicle operators are in accordance with some previous findings. Study on mechanized logging operators indicated that prevalence of "overload syndrome", characterized by complaints and injuries to the neck, arms and cervical spine was around 50% in a study group of 1174 subjects (Axelsson and Pontedn, 1990). This study had, however, no other off- road drivers but compared to prevalence of symptoms in relation to age and years of work as a machine operator. An early investigation reported that only one out of five drivers of off-road machines had symptoms mostly from the neck, but the drivers were not compared to any control group (Theorell et. al., 1988).

This study has indicated an increased risk of symptoms from thoracic region irrespective of type of industrial off-road vehicle. This section of the spine has rarely been reported as susceptible for exposure to WBV except tracked excavators. One investigation of forest employees reported a 12 months prevalence of complaints to around 8% in the thoracic region (Axelsson and Pontedn, 1990). The results from that study did not distinguish between machine operators and other employment categories, which could explain the low prevalence in relation to our findings.

Early study by Bovenziet al. (2002) showed an increased risk of low back pain among a subgroup of off-road machine drivers who also exhibited large increased risk of long-term adverse health effects on the low back pain (LBP) revealed from a standardized questionnaire in a group of 219 port machinery operators exposed to whole-body vibration. Massim and Alberto (1994) performed a study on agricultural tractor drivers who exhibited a prevalence of low back pain. A study by Burdorf et al (1993) showed that crane operators reported prevalence of back complaints. The present results indicate increased risk of low back pain among drivers of tracked excavators with breaker. Research on musculoskeletal health and spinal disorders in relation to long term exposure for ergonomic load among drivers of tracked excavators with breaker is lacking. White fingers are more common among the drivers of tracked excavators in the study compared to a cross-sectional study by Mirbod et al. (1997) who investigated traffic police motor. This study indicates that exposure to HAV (transmitted through the steering devices) could have contributed to these symptoms. It is not very likely that the vibration transmitted from the steering devices transmits all the way up to the neck, causing stress on the muscles and joints. The HTV, however, might affect the neck and shoulders indirectly with a static posture and increase muscular load. It is well-known that when exposed to HAV people have a tendency to increase their grip force (Hartung et al., 1993; Park and Martin, 1993).

Causative Factors

Exposure to shock and vibration that should occur in both horizontal and vertical directions for industrial off-road vehicles may be of particular importance, in developing symptoms of musculoskeletal disorders, as the worker has to have tensed muscles to maintain balance during exposure and to be able to handle the lever at the same time. Meanwhile, a sustained elevated arm position could cause symptoms in the neck and shoulder due to static overload of the muscles. Drivers of tracked excavators have restricted visibility partly due to the frames of the windows obstructing their view. Drivers of mobile crane may also have this problem. This can influence head postures and force the neck into strenuous and extreme positions outside the optimal range of motion. The region of neck and shoulders is often considered as one functional entity by virtue of the anatomical proximity and because musculoskeletal disorders in the neck often include symptoms in the shoulder regions and vice versa. The two regions are distinguished by means of a sketched figure carried in the questionnaire, with marked anatomical regions. There are anatomical differences, in that the thoracic part has more synovial joints in relation to other parts of the spinal column.

Typically, the joint movements in the thoracic spine are relatively small due to the anatomical construction with links to the nearby protecting rib cage preventing large range of motions. The steering passive units of the columnar and the zygopophysial joints are oriented differently compared to the neck, which may alter the susceptibility from WBV and shock. Symptoms from the thoracic region might hypothetically originate from joint structures.

Previous studies of the effects of WBV have often included drivers of heavy vehicles, e.g., fork lift trucks and trucks, and have consistently found an increased risk of low back pain [Riihimag et al (1989),Boshuizen et al (1992) & (1990)]. There are currently no WBV exposure data for industrial off-road vehicles but such

measurements are underway. However, it seems reasonable that shocks caused by uneven terrain surfaces may be transmitted to the drivers of off-road vehicles. Such vibration may have a quite different character with respect to magnitude, direction, frequency content, and prevalence of shocks compared to vibration in other vehicles. Our findings are also in contrast to our hypothesis that shock/vibration in industrial off-road vehicles should cause an increased risk of low back pain. The group that reported most frequent occurrence of unpleasant movements (shock, jolt, irregular sway), i.e., the forest machine drivers, had no increased risk of low back pain.

Consideration in the Study

This is a study which may have under estimated the risk of serious musculoskeletal symptoms, as such problems may have caused the individual to change job. The healthy worker effect may be the cause for the weak exposure-response relationship. This study has not measured the intensity of exposure in the different terrain vehicles and the exposure may differ within the groups, which is why the exposure-response relationship is not determined. The exposure will have a complex variation and interaction. Since the exclusion criteria in this study would be the most relevant to cumulative effects of operating a terrain vehicle, but not for acute ones, a parallel analysis is performed which included all potential subjects irrespective of driving time. No information was collected about other physical risk factors besides from unpleasant movements, but the exposure duration in the various vehicles indicates, apart from exposure to WBV, a working environment with prolonged static seating and repetitious arm work. The study has not investigated about occurrence of trauma in the past, which could have affected the outcome. The purpose of this study is to investigate whether larger cumulative exposure duration from operating an industrial off-road vehicle is associated with an increased risk of musculoskeletal symptoms. The awareness of a risk may have influenced the way the worker answered to the questionnaire. However, there are no economical gains from reporting a symptom in this study. Furthermore, it seems unlikely that they should have reported a high prevalence of symptoms from the neck/shoulder and not from the low back if awareness of risk could have influenced the answers. We also surveyed symptoms from the knees and there was no difference between any of the groups. Thus we consider that a biased reporting of symptoms due to awareness of risk is unlikely.

Conclusion

The results indicate that drivers of industrial tracked excavator with breaker have an increased risk of symptoms from the neck, shoulder, back region and hand arm regions. There is no enlarged risk of low back pain in operators of compaction roller, mobile crane and industrial trucks comparatively. This indicates that factors such WBV and HTV may be important in determining the risk of symptoms in the neck, shoulder, back regions and hand-arm.

References

Axelsson S.A. and B.Pontedn, New Ergonomic Problems In Mechanized Logging Operations. *International Journal of Industrial Ergonomics* 1990; 5, 267-273.

Theorell T., A. Perski, T. A Kerstedt, F. Sigala, G. Ahlberg-Hultedn, J. Svensson And P. Eneroth Changes In Job Strain In Relation To Changes In Physiological State,. *Scandinavian Journal Of Work, Environment and Health* 1988; 14, 189-196.

Bovenzia M., I. Pintob and N. Stacchini Low Back Pain In Port Machinery Operators. *Journal Of Sound And Vibration* 2002; 1, 3-20.

Massimo Bovenzi, Alberto Betta Low-Back Disorders In Agricultural Tractor Drivers Exposed To Whole-Body Vibration And Postural Stress. *Applied Ergonomics* 1994;25(4): 231-241.

Burdorf A, Naaktgeboren B, De Groot Hcwm Occupational Risk Factorsfor Low Back Pain Among Sedentary Workers, *J Occuo Med 1993;* 35:1213-1220.

Mirbod Et Al., S. Mirbod, H. Yoshida, M. Jamali, K. Masamura, R. Inaba And H. Iwata, Assessment Of Hand-Arm Vibration Exposure Among Traffic Police Motorcyclists, *Int. Arch. Occup. Environ. Health* 1997; 70:22–28.

Hartung Et Al., 1993 E. Hartung, H. Dupuis And M. Scheffer, Effects Of Grip And Push Forces On The Acute Response Of The Hand-Arm System Under Vibrating Conditions, *Int. Arch. Occup. Environ. Health* 1993;64:463–467.

Park And Martin, 1993 H.S. Park And B.J. Martin, Contribution Of The Tonic Vibration Reflex To Muscle

Stress And Muscle Fatigue, *Scand. J. Work Environ. Health* 1993; 19: 35–42.

H. Riihimag Ki, S. Tola, T. Videman And K. Hag Nninen 1989 A Cross-Sectional Questionnaire Study Of Men In Machine Operating, Dynamic Physical Work, And Sedentary Work.*Spine* 14, 204-209.

Boshuizen H. C., P.M.Bongers and C. T. J. Hulshof, Self-Reported Back Pain In Fork-Lift Truck And Freight-Container Tractor Drivers Exposed To Whole-Body Vibration. *Spine* 1992; 17:59-65.

Boshuizenh. C., P. M. Bongers and C. T. J. Hulshof, Self-Reported Back Pain In Tractor Drivers Exposed To Whole-Body Vibration. International Archives Of Occupational And Environmental Health 1990; 62: 117-122.